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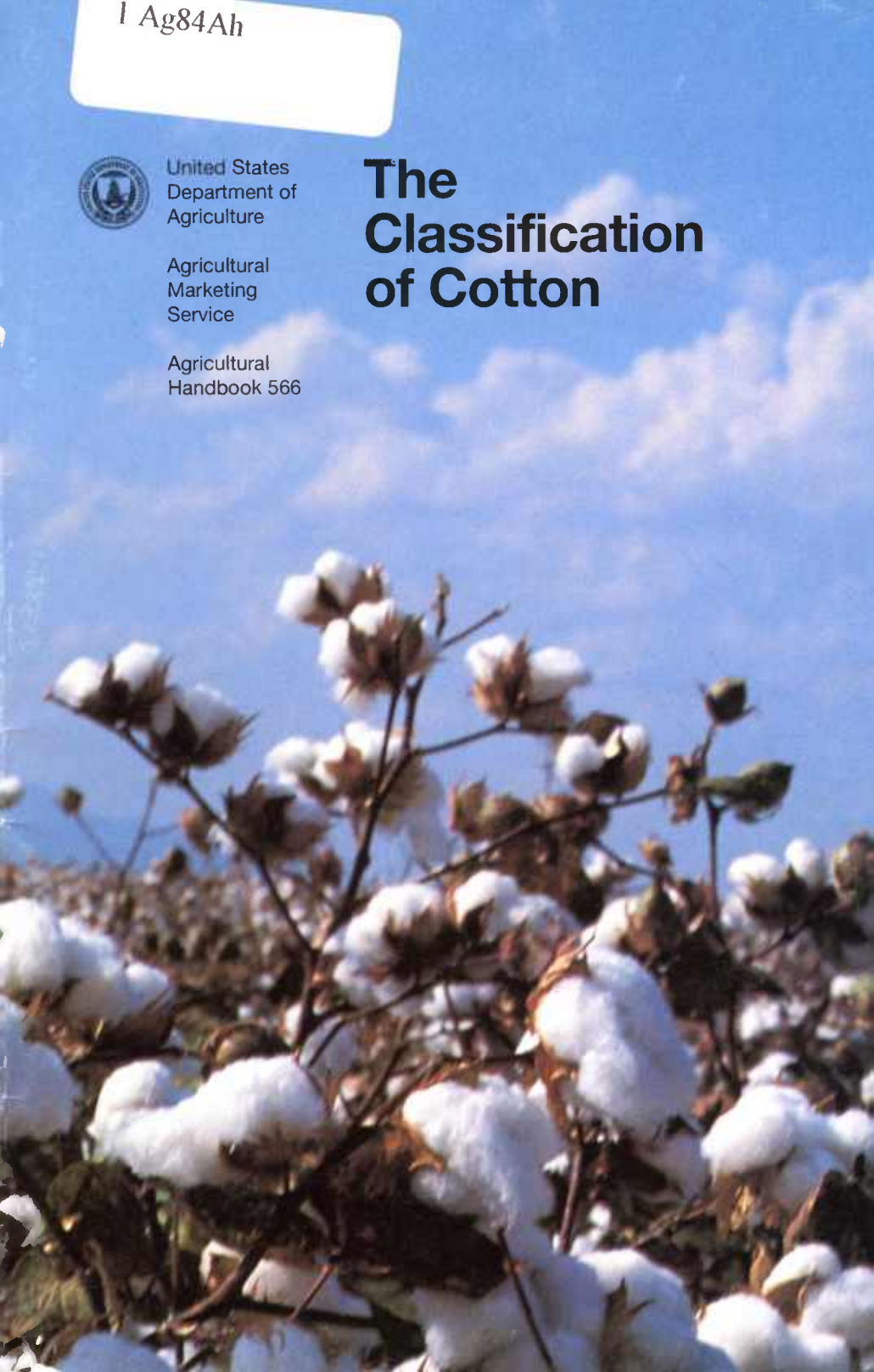
Handbook 566

The Classification of Cotton



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I. Introduction

In 1907, an international group of cotton industry representatives met in Atlanta, Georgia, to address serious problems that had developed in the marketing of cotton. A resolution was passed, which recommended the establishment of uniform cotton standards to "eliminate price differences between markets, provide a means of settling disputes, make the farmer more cognizant of the value of his product, and, therefore, put him in a better bargaining position, and in general be of great benefit to the cotton trade." In response to this and similar calls for action over the next several years, laws were passed authorizing the United States Department of Agriculture (USDA) to develop cotton grade standards and offer cotton classification services. Thus began an industry-government relationship which remains strong and viable to this day. This long-standing partnership demonstrates how government and industry can work together, each respectful of the other's role, to produce continuing beneficial results for the Nation, and for its customers abroad.

II. Overview

Nature of Cotton

Botanically, there are three principal groups of cotton that are of commercial importance. The first group (Gossypium hirsutum) is native to Mexico and Central America and has been developed for extensive use in the United States, accounting for more than 95 percent of U.S. production. This group is known in the United States as American Upland cotton, and varies in length from about 7/8 to 1 5/16 inches. A second botanical group (G. barbadense), which makes up the balance of U.S. production, is of early South American origin. Varying in length from 1 1/4 to 1 9/16 inches, it is known in the United States as American Pima, but is also commonly referred to as Extra Long Staple (ELS) cotton. A third group (G. herbaceum and G. arboreum) embraces cottons of shorter length, 1/2 to 1 inch, that are native to India and Eastern Asia. None from this group is grown in the United States.

In a single pound of cotton, there may be 100 million or more individual fibers. Each fiber is an outgrowth of a single cell that develops in the surface layer of the cotton seed. During the early stages of its growth, the fiber

USDA operates 14 cotton classing facilities strategically located across the Cotton Belt. The facilities are specifically designed to use high-volume instrument (HVI) classification. Temperature and numidity inside the facilities are tightly controlled to ensure accurate and precise measurements of all samples.

elongates to its full length as a thin-walled tube. As it matures, the fiber wall is thickened by deposits of cellulose inside the tube, leaving a hollow area in the center. When the growth period ends and the living material dies, the fiber collapses and twists about its own axis.

Classification

The term "cotton classification" in this publication refers to the application of standardized procedures developed by USDA for measuring those physical attributes of raw cotton that affect the quality of the finished product and/or manufacturing efficiency. USDA classification currently consists of determinations of fiber length, length uniformity, strength, micronaire, color, preparation, leaf and extraneous matter. Research and development for the technology to rapidly measure other important fiber characteristics, such as maturity and short fiber content, continues.

Authority

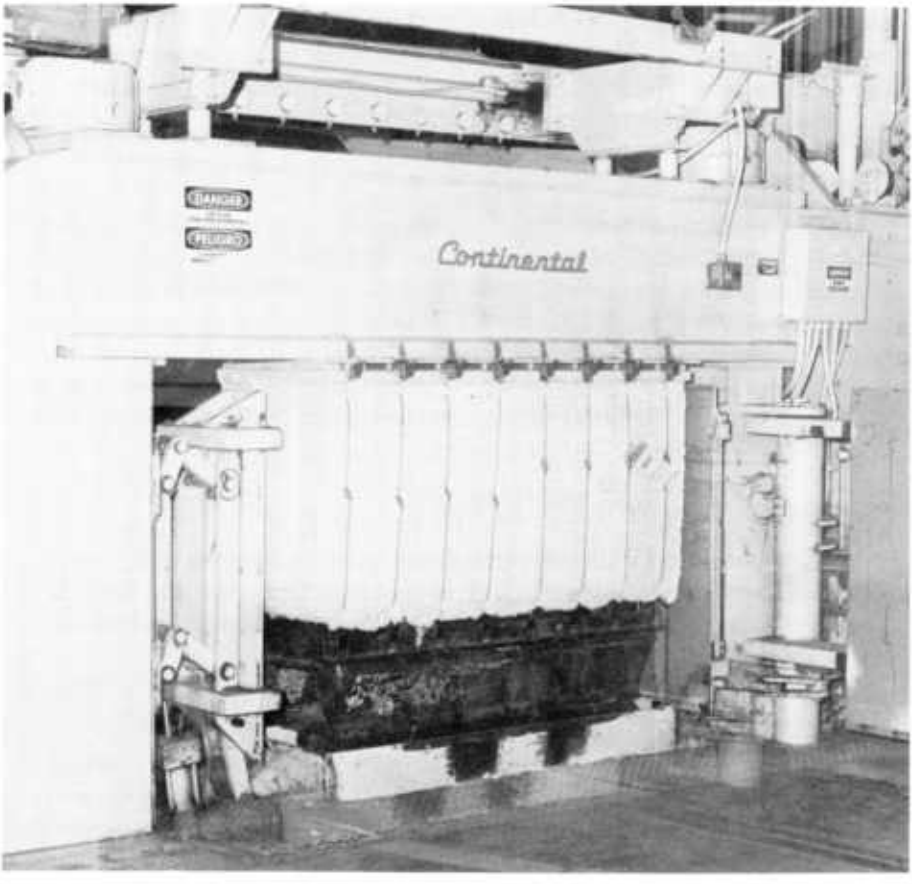
USDA cotton classification services are authorized by the U.S. Cotton Statistics and Estimates Act, the U.S. Cotton Standards Act, and the U.S. Cotton Futures Act. All users of the service are charged a fee to recover classification costs.

Scope

Practically all cotton grown in the United States is classed by USDA at the request of producers. While classification is not mandatory, growers generally find it essential to marketing their crop and for participation in the USDA price support program. USDA also classes all cotton tendered for delivery on futures contracts on the New York Cotton Exchange and provides arbitration classing to the industry. Classification services also are provided to individual buyers, manufacturers, breeders, researchers, and others upon request.

Facilities

USDA operates 14 cotton classing facilities across the Cotton Belt. The facilities are designed specifically for cotton classification and are staffed exclusively with USDA personnel. Their locations are shown inside the back cover.



After the cotton fibers are separated from the seed, cleaned to remove plant residue and other foreign material, and pressed into bales at the gin, a 4-ounce sample is taken from each side of the bale by a licensed sampling agent and forwarded to USDA for official classification.

Sampling

At the gin, cotton fibers are separated from the seed, cleaned to remove plant residue and other foreign material, and pressed into bales of about 500 pounds. A sample of at least 4 ounces (114 grams) is taken from each side of the bale by a licensed sampling agent and delivered by the agent or designated hauler to the USDA classing facility serving the area. Gin and warehouse operators serve as licensed sampling agents and perform this function under USDA supervision.

Sample Processing

Upon arrival at the USDA classing facility, samples are conditioned to bring the moisture content to specified ranges before the classing process begins. Samples are delivered to classing stations by conveyor belt. Fiber measurement results are electronically sent to the classing facility's computerized data base and are immediately available to the customer. The classing process stays abreast of the ginning of the crop, providing producers and buyers with crucial quality information at time of sale. At the peak of the season, USDA classes and provides data on as many as 2 million bales per week, nationwide. Sample remnants are sold by USDA, with proceeds applied to classification costs.

Classing Methodology

USDA's classing methodology is constantly updated to include state-of-the-art methods and equipment to provide the cotton industry with the best possible quality information for marketing and processing. The system is rapidly moving from reliance on human senses to the utilization of high-volume, precision instruments that perform quality measurements in a matter of seconds. USDA will complete the transition to all-instrument classification as quickly as the technology can be developed and instruments are sufficiently refined..

Dissemination of Data

Cotton classification data are available to producers or their authorized agents through computer-to-computer telecommunications, diskettes, tapes, punched cards, and computer-generated printed documents. The most popular method of dissemination is telecommunications, because it gives the customer immediate access to data upon classification. The data are avail-

Samples are collected, usually on a daily basis, from sampling points and delivered to the USDA classing facility serving that area.

able to subsequent owners of the cotton, primarily merchants and manufacturers, through a computerized central data base. This data base is accessible by telecommunications and contains classification data for the current and past year's crop. Access to the classification data is limited to the current owner of the cotton.

III. Classification of Upland Cotton

A. Instrument Determinations

Measurements for the following quality factors are performed by high-volume, precision instruments. This method is commonly referred to as "HVI" classification.

Fiber Length

Fiber length is the average length of the longer one-half of the fibers (upper half mean length). It is reported in both 100ths and 32nds of an inch (see conversion chart below). It is measured by passing a "beard" of parallel fibers through a sensing point. The beard is formed when fibers from a sample of cotton are grasped by a clamp, then combed and brushed to straighten and parallel the fibers.

Upland Length Conversion Chart

32nds	Inches	32nds	Inches
24	0.79 & shorter	36	1.11 - 1.13
26	.80 - .85	37	1.14 - 1.17
28	.86 - .89	38	1.18 - 1.20
29	.90 - .92	39	1.21 - 1.23
30	.93 - .95	40	1.24 - 1.26
31	.96 - .98	41	1.27 - 1.29
32	.99 - 1.01	42	1.30 - 1.32
33	1.02 -1.04	43	1.33 - 1.35
34	1.05 -1.07	44 & longer	1.36 & longer
35	1.08 -1.10		

Fiber length is largely determined by variety, but the cotton plant's exposure to extreme temperatures, water stress, or nutrient deficiencies may shorten the length. Excessive cleaning and/or drying at the gin may also result in shorter fiber length.

Fiber length affects yarn strength, yarn evenness, and the efficiency of the spinning process. The fineness of the yarn that can be successfully produced from given fibers is also influenced by the length of the fiber.

Length Uniformity

Length uniformity is the ratio between the mean length and the upper half mean length of the fibers and is expressed as a percentage. If all of the fibers in the bale were of the same length, the mean length and the upper half mean length would be the same, and the uniformity index would be 100. However, there is a natural variation in the length of cotton fibers, so length uniformity will always be less than 100. The following table can be used as a guide in interpreting length uniformity measurements.

Degree of Uniformity	HVI Length Uniformity Index (Percent)
Very High	Above 85
High	83 - 85
Intermediate	80 - 82
Low	77 - 79
Very Low	Below 77

Length uniformity affects yarn evenness and strength, and the efficiency of the spinning process. It is also related to short fiber content (fiber shorter than one-half inch). Cotton with a low uniformity index is likely to have a high percentage of short fibers. Such cotton may be difficult to process and is likely to produce low-quality yarn.

Fiber Strength

Strength measurements are reported in terms of grams per tex. A tex unit is equal to the weight in grams of 1,000 meters of fiber. Therefore, the strength reported is the force in grams required to break a bundle of fibers one tex unit in size. The following tabulation can be used as a guide in interpreting fiber strength measurements.

Degree of Strength	HVI Strength (grams per tex)
Very Strong	31 & above
Strong	29 - 30
Average	26 - 28
Intermediate	24 - 25
Weak	23 & below

Strength measurements are made on the same beards of cotton that are used for measuring fiber length. The beard is clamped in two sets of jaws, one-eighth inch apart, and the amount of force required to break the fibers is determined. Fiber strength is largely determined by variety. However, it may be affected by plant nutrient deficiencies and weather.

There is a high correlation between fiber strength and yarn strength. Also, cotton with high fiber strength is more likely to withstand breakage during the manufacturing process.

Micronaire

Micronaire is a measure of fiber fineness and maturity. An airflow instrument is used to measure the air permeability of a constant mass of cotton fibers compressed to a fixed volume. The chart below can be used as a guide in interpreting micronaire measurements.

Upon arrival at the USDA classing facility, samples are conditioned to standardize moisture content before the classing process begins.

Relationship of Micronaire Readings to Market Value

Micronaire measurements can be influenced during the growing period by environmental conditions such as moisture, temperature, sunlight, plant nutrients, and extremes in plant or boll population.

Fiber fineness affects processing performance and the quality of the end product in several ways. In the opening, cleaning, and carding processes, low-micronaire, or fine-fiber, cottons require slower processing speeds to prevent damage to the fibers. Yarns made from finer fiber result in more fibers per cross-section, which in turn produces stronger yarns. Dye absorbency and retention varies with the maturity of the fibers. The greater the maturity, the better the absorbency and retention.

Color

The color of cotton is determined by the degree of reflectance (Rd) and yellowness (+b). Reflectance indicates how bright or dull a sample is, and yellowness indicates the degree of color pigmentation. A three-digit color code is used. The color code is determined by locating the point at which the Rd and +b values intersect on the Nickerson-Hunter cotton colorimeter diagram for Upland cotton (see Exhibit A on page 22).

The color of cotton fibers can be affected by rainfall, freezes, insects and fungi, and by staining through contact with soil, grass, or the cotton plant's leaf. Color also can be affected by excessive moisture and temperature levels while cotton is being stored, both before and after ginning.

As the color of cotton deteriorates due to environmental conditions, the probability for reduced processing efficiency is increased. Color deterioration also affects the ability of fibers to absorb and hold dyes and finishes.

Utilizing the latest technology and equipment, samples are classed on an assembly line arrangement with fiber measurement results electronically transmitted to the classing facility's computerized data base.

Trash

Trash is a measure of the amount of non-lint materials in the cotton, such as leaf and bark from the cotton plant. The surface of the cotton sample is scanned by a video camera and the percentage of the surface area occupied by trash particles is calculated. Although the trash determination and classer's leaf grade (see page 15) are not the same, there is a correlation between the two as shown in the table below.

Relationship of trash measurement to classer's leaf grade

Trash Measurement (4-yr. Avg.) (% area)	Classer's Leaf Grade
0.08	1
.12	2
.18	3
.34	4
.55	5
.86	6
1.56	7

B. Classer Determinations

Although USDA provides instrument measurements of color and trash, the traditional method of classer determination for color, leaf, and extraneous matter remains useful to the cotton industry and continues to be included as part of the official USDA classification.

Classification results, maintained by the local classing facility on a computerized data base, are available to growers or their agents immediately upon classification. The standard means of data dissemination is by computer-to-computer telecommunications. Individual bale data are available only to the current owner of the cotton. Upon acquiring title to the cotton, merchants and manufacturers may obtain the data from a Beltwide central data base.

Color Grade

There are 25 official color grades for American Upland cotton, plus five categories of below grade color, as shown in the tabulation below. USDA maintains physical standards for 15 of the color grades. The others are descriptive standards.

Color Grades of Upland Cotton
Effective 1993

	White	Light Spotted	Spotted	Tinged	Yellow Stained
Good Middling	11*	12	13	—	—
Strict Middling	21*	22	23*	24	25
Middling	31*	32	33*	34*	35
Strict Low Middling	41*	42	43*	44*	—
Low Middling	51*	52	53*	54*	—
Strict Good Ordinary	61*	62	63*	—	
Good Ordinary	71*	—	—	—	—
Below Grade	81	82	83	84	85

* Physical Standards. All others are descriptive.

Leaf Grade

The classer's leaf grade is a visual estimate of the amount of cotton plant leaf particles in the cotton. There are seven leaf grades, designated as leaf grade "1" through "7", and all are represented by physical standards. In addition, there is a "below grade" designation, which is descriptive.

Leaf content is affected by plant variety, harvesting methods, and harvesting conditions. The amount of leaf remaining in the lint after ginning depends on the amount present in the cotton prior to ginning, and on the type and amount of cleaning and drying equipment used. Even with the most careful harvesting and ginning methods, a small amount of leaf remains in the cotton lint.

From the manufacturing standpoint, leaf content is all waste, and there is a cost factor associated with its removal. Also, small particles cannot always be successfully removed and these particles may detract from the quality of the finished fabric.

Preparation

Preparation is the classer's determination of the degree of roughness or smoothness of the ginned lint cotton. The harvesting and ginning of cotton that contains too much moisture may result in lint cotton with a twisty, knotty appearance. Such cotton is difficult to process and produces inferior yarn. Abnormal preparation in Upland cotton has greatly diminished in recent years, due to improvements in harvesting and ginning practices, and now occurs in less than one-half of 1 percent of the crop.

Extraneous Matter

Extraneous matter is any substance in the cotton other than fiber or leaf. Examples of extraneous matter are bark, grass, spindle twist, seedcoat fragments, dust, and oil. The kind of extraneous matter, and an indication of the amount (light or heavy), are noted by the classer on the classification document.

IV. Classification of American Pima Cotton

Classification procedures for American Pima cotton are similar to those for American Upland cotton, including instrument measurements. Different grade standards are used because the color of American Pima cotton is a deeper yellow than that of Upland (see exhibit B, American Pima colorimeter diagram). Also, the ginning process for American Pima cotton (roller ginned) is not the same as for Upland (saw ginned). The roller gin process results in an appearance that is not as smooth as that of the saw ginned process.

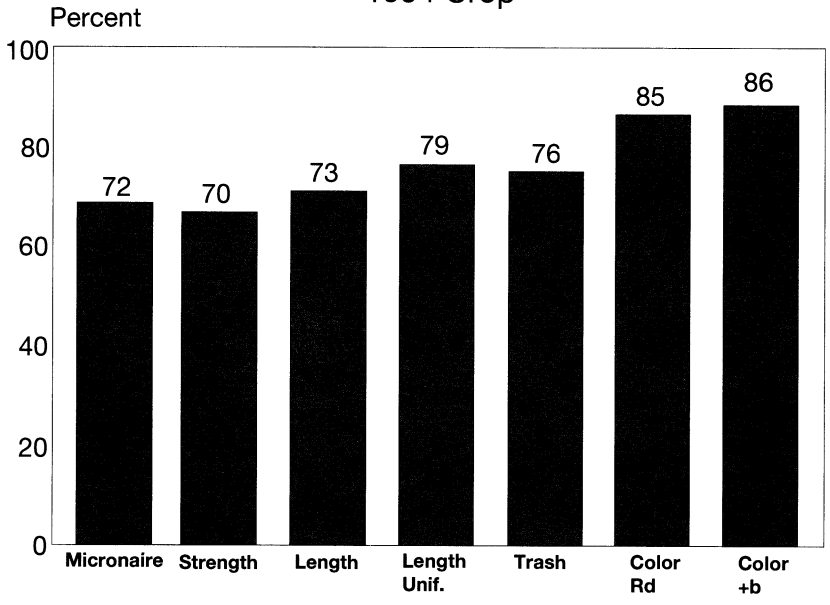
There are six official grades (grades "1" through "6") for American Pima cotton, all represented by physical standards, plus below grade, which is descriptive. A different chart is used to convert American Pima fiber length from 32nds to 100ths of an inch. This chart is below.

American Pima Length Conversion Chart

32nds	Inches
40	1.20 and lower
42	1.21 - 1.25
44	1.26 - 1.31
46	1.32 - 1.36
48	1.37 - 1.42
50	1.43 - 1.47
52	1.48 and above

V. Reliability of Classification Data

The reproducibility of classing results from one USDA facility to another is the measure used by USDA to determine the reliability of the data it produces. Laboratory-to-laboratory reproducibility is more difficult to achieve than within-lab or same-machine reproducibility, because it is more difficult to maintain identical testing conditions. A comparison of laboratory-to-laboratory results provides a more realistic assessment of the degree of reproducibility that can be expected in the manufacturer's laboratory after shipment to the textile mill. The tabulation on page 18 reflects USDA lab-to-lab reproducibility as of 1994. These results are based on more than 100,000 check-lot samples, randomly selected, daily, from the production of each instrument line and each classer at each USDA classing facility throughout the 1994 season and retested at the agency's Quality Control unit in Memphis.



Results were obtained with permitted tolerances of: Length, 0.02 inches; Length Unif., 1.0 percent; Strength, 1.5 g/tex; Micronaire, 0.1 units; Color Rd, 1.0 units; Color +b, 0.5 units; Trash, 0.1 % area.

VI. Quality Control

Process Control

Process capability studies of classing equipment operated by USDA are carried out periodically to determine the overall capability of the equipment with regard to accuracy. In turn, the study results are used to establish tolerance limits for measurement variations.

Equipment Performance Specifications

Minimum performance specifications of classing equipment are an integral part of the USDA procurement process. Specifications for the delivery of new equipment in 1995 included the following maximum allowable tolerances for accuracy and precision.

Fiber Property	Accuracy	Precision
Length (inch)	± 0.018	± .012
Uniformity (percent)	± 1.200	± .800
Strength (g/tex)	± 1.500	± 1.000
Micronaire (units)	± .150	± .100
Color (Rd) (units)	± 1.000	± .700
Color (+b) (units)	± .500	± .300
Trash (% area)	± .100	± .040

The term "accuracy" refers to how well an instrument measures a certain property in relation to its true value. The term "precision" refers to the ability of an instrument to produce the same measurement result time after time.

Laboratory Conditioning

Atmospheric conditions influence the measurement of cotton fiber properties. Therefore, the temperature and humidity of the classing laboratory must be tightly controlled. Temperature is maintained at 70 °F, plus or minus 1 degree, and relative humidity is maintained at 65 percent, plus or minus 2 percent.

Sample Conditioning

Samples are conditioned to bring the moisture content of all samples within the range of 6.75 percent to 8.25 percent.

Laboratory Lighting

Lighting conditions in USDA laboratories are maintained to provide a minimum of 100 foot-candles of illumination at the classing level. Special lamps are used to provide the best true color perception. All surfaces in the laboratories are white, gray, or black, and the walls are off-white, to further enhance color perception.

Selection of Cotton for Calibration Usage

Cotton used for instrument calibration must pass rigorous screening procedures. As a first step, USDA conducts an intensive search for the most uniform bales of cotton in the current crop. Candidate bales are screened for uniformity of fiber quality by testing 12 samples drawn from throughout each bale. Bales that do not produce highly uniform measurement results are eliminated from further consideration. Bales that pass preliminary screening then undergo detailed analysis, as described below, to determine whether they meet USDA's high standards for certification and use as calibration cottons.

Establishing Values for Calibration Cotton

Currently, five laboratories work together to establish values for calibration cottons; three are USDA facilities and two are independent laboratories from the research community. The independent labs have atmospheric conditioning equal to USDA labs. The laboratories perform a total of 220 tests per bale and the results are used to determine the values assigned to calibration cottons. For reference purposes, samples of previously established, or "benchmark," calibration cottons are included in the testing, along with samples from the candidate bales. If the test results within a bale exceed prescribed limits, the bale is rejected. If all testing criteria are met, the bale is accepted and its contents packaged for distribution as calibration cotton.

Calibration of Instruments

Instruments are calibrated for length, length uniformity, micronaire, and strength by using calibration cottons. Tiles are used to calibrate color and trash measurements. A calibration check is made at equipment startup and every 2 hours during each operating shift. Calibration tolerances for 1995 are:

Quality Factor Tolerance

Micronaire (units)	± 0.100
Color Rd (units)	± .300
Color +b (units)	± .300
Trash (% area)	± .050
Length (inches)	± .015
Uniformity (percent)	± 1.000
Strength (grams/tex)	± .700

Check Samples

In addition to calibration, samples of known value are tested on each instrument several times each 8-hour shift. If the test value deviates from the known value by more than specified tolerance limits, corrective action is taken.

Checklot Program

USDA's Checklot Program ensures that all USDA classification facilities across the Cotton Belt provide uniform test results. Under this program, random samples are computer-selected from the production of each instrument line and classer during each work-shift. These samples are forwarded by overnight delivery to USDA's Quality Control unit in Memphis, Tennessee, where they are retested. Results are compared with the original classification, and this information is immediately telecommunicated back to the originating office where level adjustments are made as necessary. USDA maintains a record of comparisons for each instrument and classer on a daily, weekly, and seasonal basis. Results of the Checklot Program for the 1994 crop are reported on page 18.

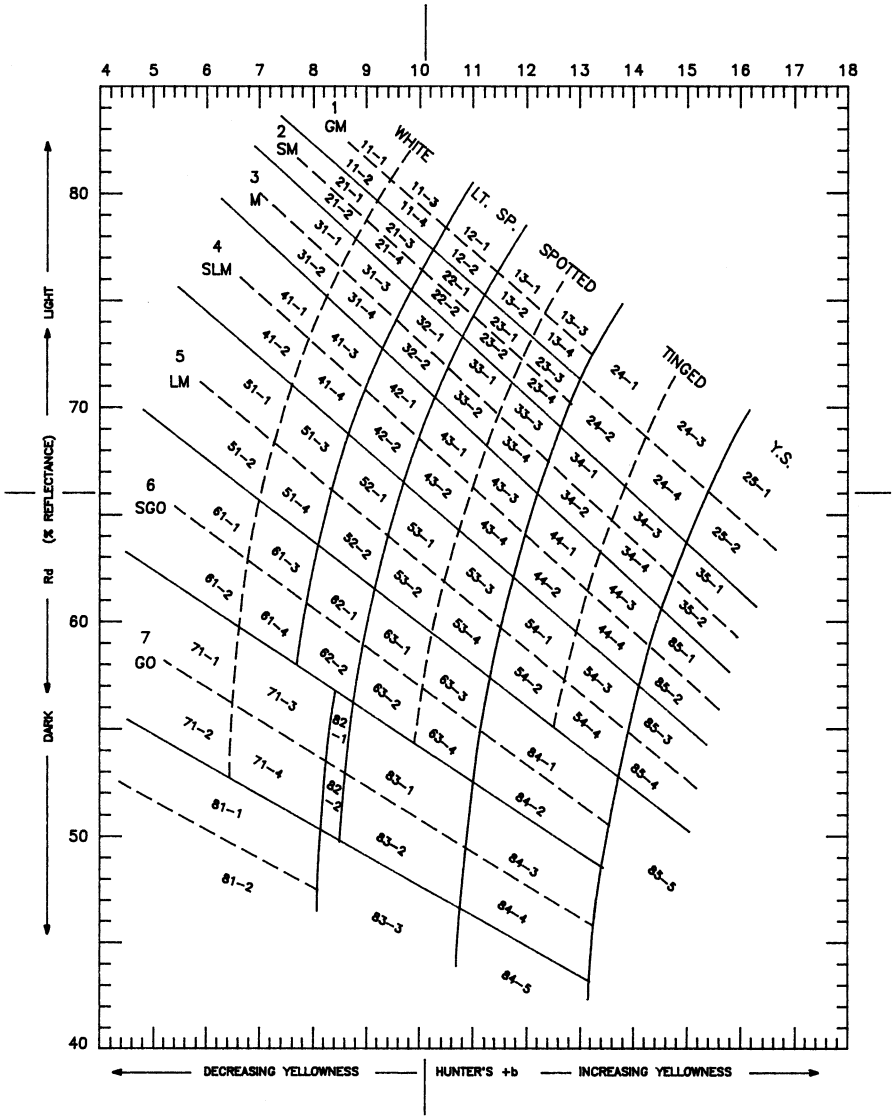


Exhibit A

Color Chart for American Upland Cotton

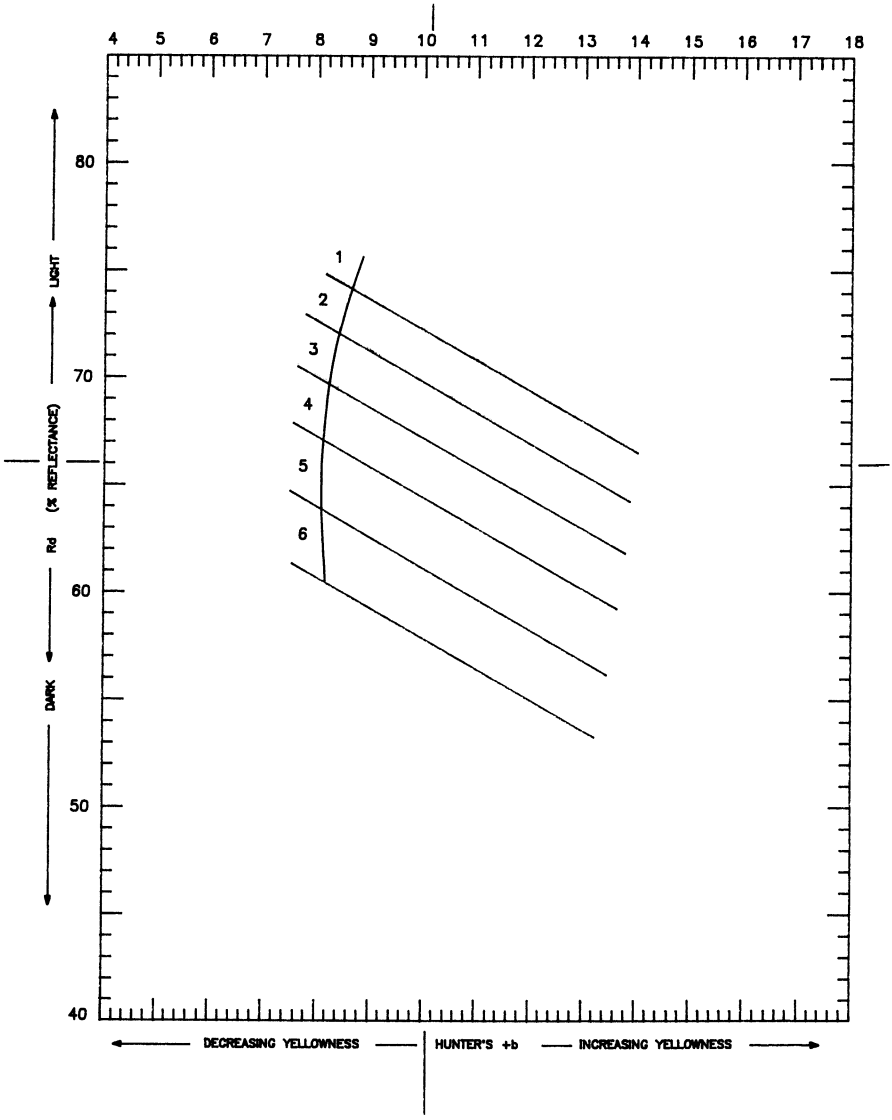
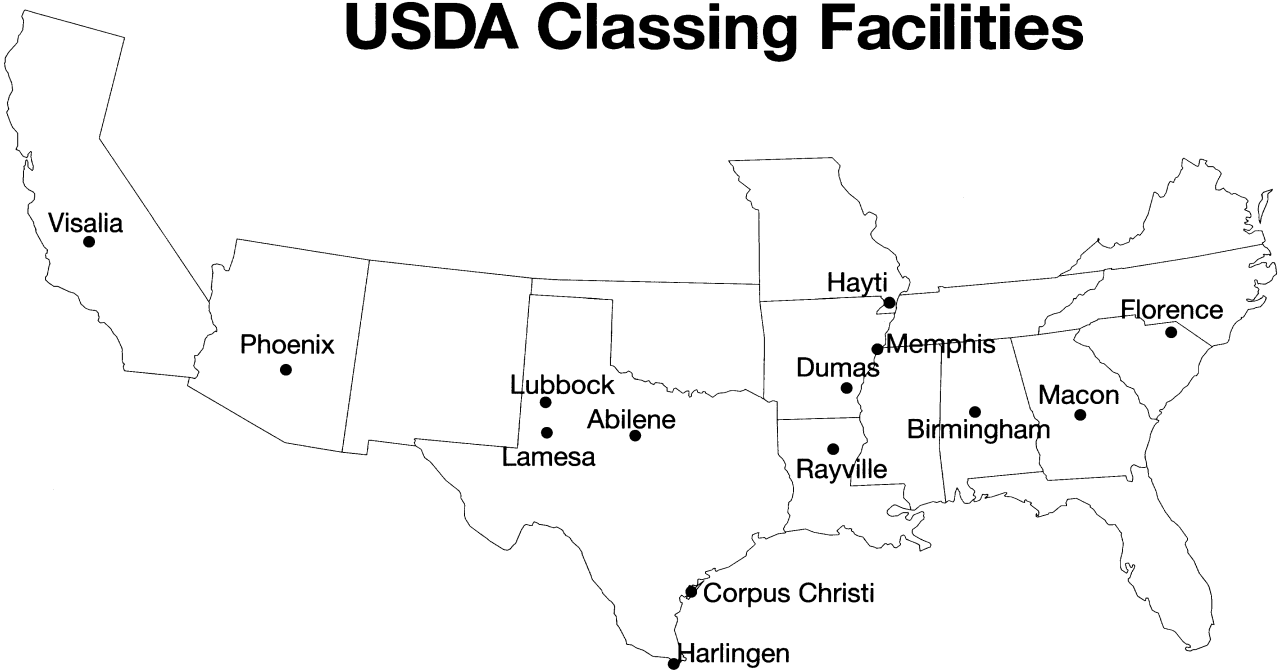


Exhibit B

Color Chart for American Pima Cotton

USDA Classing Facilities



To order additional copies of this publication or to obtain further information about USDA's Cotton Classing Program contact: Cotton Division, AMS, USDA, 3275 Appling Road, Memphis, TN 38133
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